Methodical Support for Development of Operational Requirements

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ABSTRACT

The development of Operational Requirements (OR) for military platforms is a complex and tedious task, for which many aspects need to be addressed (integral) and for which few tools are available. This task is usually performed by temporary placed military personnel trying their best to deliver a list of relevant OR. The RNLA has a need for a methodical approach and associated tools, providing a means to enhance the quality but also the re-use of OR. Key is an integral approach not only aimed at the functionality of the platform but also at the crew and many other relevant and interacting viewpoints.

The paper gives a description of the process to arrive at a set of operational requirements and a description of the tools that may be used to support the process. A distinction is made between new OR for systems and mid-life upgrades and mission dependent add-ons. Fictitious examples are given in the description and explanation.

1.0 BACKGROUND

The research project 'Integral Analysis of Platform Performance' (IAPP) aims at the analysis of platform performance from an integral point of view. In the project a method has been derived to answer questions related to the performance of RNLA platforms (land, sea or air). Until recently detailed performance analysis was done on different disciplines in separate lanes. The influence and effect of disciplines on each other was not taken into account which sometimes led to unwanted results. A systems engineering approach has been chosen to include different disciplines and to consider a platform from many different viewpoints. To address performance analysis in an integral way as many aspects as are necessary need to be considered, given the question at hand.

The IAPP method is based on a four level approach. The levels vary in detail and differ in integrality. Two levels are based on the use of expert knowledge and two levels are based on the use of modelling, simulation and experimentation.

The IAPP method has been tried out in a case study. The case comprised a fictitious platform which needed to be compared to some alternative existing platforms. To be able to compare the systems, a set of characteristics and operational requirements were defined for the fictitious platform. During this process several tools were created and used. The case has been shown to RNLA staff, resulting in formalisation of the used method and tools and start of a software implementation. Software tools are currently under development.

The tools comprise a set of libraries containing many aspects denoting different viewpoints. Each aspect system is a hierarchical subdivision (tree) of a specific main aspect build from a certain view on the system. A system function tree is one of the important aspect systems. Other main aspect systems include environmental aspects, target types, platform types and threat types.

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The development of Operational Requirements (OR) for military platforms is a complex and tedious task, for which many aspects need to be addressed (integral) and for which few tools are available. This task is usually performed by temporary placed military personnel trying their best to deliver a list of relevant OR. The RNLA has a need for a methodical approach and associated tools, providing a means to enhance the quality but also the re-use of OR. Key is an integral approach not only aimed at the functionality of the platform but also at the crew and many other relevant and interacting viewpoints. The paper gives a description of the process to arrive at a set of operational requirements and a description of the tools that may be used to support the process. A distinction is made between new OR for systems and mid-life upgrades and mission dependent add-ons. Fictitious examples are given in the description and explanation.

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2.0 DEVELOPMENT OF OPERATIONAL REQUIREMENTS

Operational requirements describe what the RNLA expects of a platform. They describe what a platform should be able to do, to perform. The process to come to operational requirements is complex. Many aspects need to be addressed during different phases. Each phase building upon the previous one, detailing requirements and solutions. We address the phase where the type of platform has already been decided and further operational requirements need to be written. The method to support the development of operational requirements helps to address the many aspects in a methodical way, providing access to an extensive list of aspects.

Figure 2 shows an IDEF0 process schema of the method. Figure 1 gives an explanation of the elements in the IDEF0 schema.

Figure 1: Explanation of IDEF0 process.

The process starts with the formulation of the needed defence capacity. The military need (the capability gap) is the input and platform type restricts the type of capacity. In the process the tasks and environment are also formulated. They act as constraints on the subsequent process steps. With the 'defence capacity' a selection is made of the aspects that are relevant for the capacity. The selected aspects, the defence capacity and tasks & environment restrictions are used to generate a system tree. The system tree nodes are then visited and attributes are collected, followed by entering normative values for the system node attributes. Finally the results are stored as Operational Requirements.

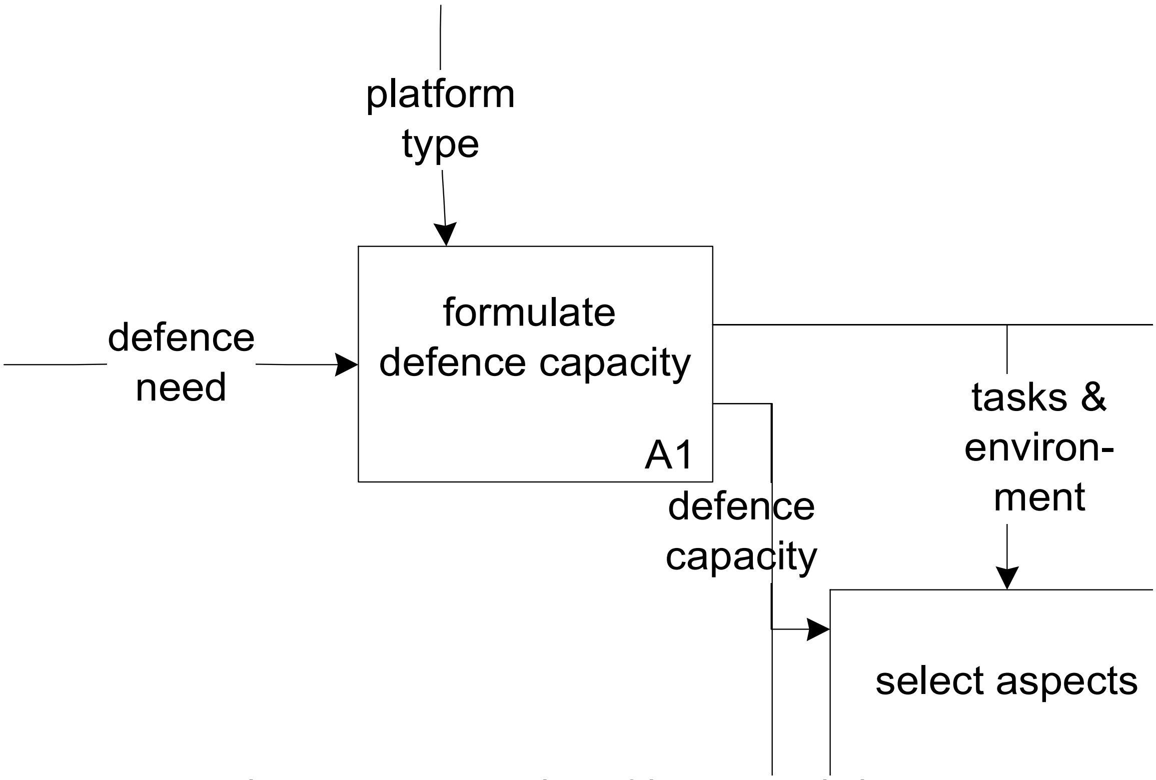

Figure 2: IDEF0 process schema of the support method.

2.1 Describe required defence capacity

The first step is to determine what defence capacity is required. Defence capacity is aimed at carrying out defence tasks.

A defence capacity can be described as follows:

the platform should be able to do XYZ / deliver KLM effects, in compliance with constraints ABC

Aspects support the formulation of XYZ, KLM, ABC and norms with respect to XYZ, KLM and ABC. Aspect checklists enable selection of relevant aspects. Some aspects are strongly related to the primary functions of the RNLA. Other aspects are related to secondary functions and usage, and some aspects act as constraints which the platform has to comply with.

The defence capacity determines what tasks need to be carried out, in what environments and what effects are to be addressed. There are no predefined capacities in the libraries.

Defence capacity should be formulated in terms of functional aspects. Anti-tank capacity can be formulated in terms of targets, i.e. tanks, environment, e.g. range, cultivation, e.g. urban, climates, e.g. arctic, geographic locations, etc. which pose additional constraints with respect to the formulation of OR.

2.2 Describe what tasks need to be carried out

One step is to describe what tasks are to be carried out by the system. Tasks describe what a system is used for. Tasks may be described in many ways, and address different levels of detail.

Military tasks are classified in a limited number of classes, each with their specifics. Task descriptions need to be on platform level, and platforms need to be able to carry out the tasks. There is no advantage in describing them on other levels. The majority of tasks can be done as a combination of the following system (platform) tasks:

- manoeuvre;
- protect;
- observe;
- communicate;
- bring out effect.

2.3 Determine what environments will be addressed

Several aspects are addressed in the environmental aspects. They comprise climate, geographic location, area cultivation (green field, urban, woods, planar …), weather and last but not least target types.

Environmental aspects introduce variations in variables which influence system performance. For climatic and geographic environments associated physical parameters such as humidity, temperature, atmospheric pressure influence physical performance of components of the system. And operations in urban environments pose restrictions, for example, on barrel length and elevation possibilities.

Humidity and atmospheric pressure for instance influence engine power / engine performance. The lower the pressure, the less power is generated and the less the engine performs. In high countries with low atmospheric pressure system performance reduces because of the reduction in engine power. Environmental aspects assist the OR developer to think about these influences.

The other environmental aspect addresses expected target systems. Different targets have different characteristics requiring different degrees of loads and damage mechanisms. They react differently to similar degrees of load and the results of attack generate different effects on e.g. insurgents and own people. A distinction is therefore made between infrastructural targets, personnel targets and equipment targets. To injure personnel targets an anti-tank weapon is clearly overkill. A capacity to eliminate a tank however needs a similar capacity as an anti-tank system. A similar reasoning can be set up for infrastructural targets.

2.4 Determine what aspects and aspect systems will be addressed

The aspect library assists in signifying relevant aspects. The aspect library contains collected aspect systems and characteristics which describe each aspect, characterise it and value it. Aspect systems, individual aspects and sub aspects may be selected. The OR developer is encouraged to think about shown characteristics and decide on possible values.

The aspect systems comprise a range of viewpoints. Viewpoints concerning functionality, but also viewpoints concerning political impact of a system. The life-cycle of a system is taken into account and other logistics aspects.

2.5 Generate system trees

A system is a set of elements and the relations between those elements, and is determined by a viewpoint. A generic system tree is based on a functional viewpoint and contains functional components and

subsystems. Each system node can be considered a component (no further breakdown needed or possible) or a subsystem fulfilling a specific function. A system node contains characteristics which describe the component. The characteristics are used for registration of operational requirements. The generic system tree contains many functional subsystems and components which may fulfill a range of functions. Some examples are:

- mobility system

The mobility system contains all components and subsystems responsible for moving the platform. A land platform e.g. contains the propulsion system with engine, propulsion, suspension, tracks or wheel. For a sea platform it does not contain suspension, tracks or wheels, but includes screw and screw axes.

- firepower system

The firepower system contains weapon systems belonging to a platform. For instance the main gun of a main battle tank, the coaxial gun for close combat and the weapon systems in use by personnel inside and outside the platform. Target acquisition systems also play a role in the protection system.

- protection system

The protection system can work passively, actively and re-actively. Also systems that reduce a platform signature are counted to the protection system.

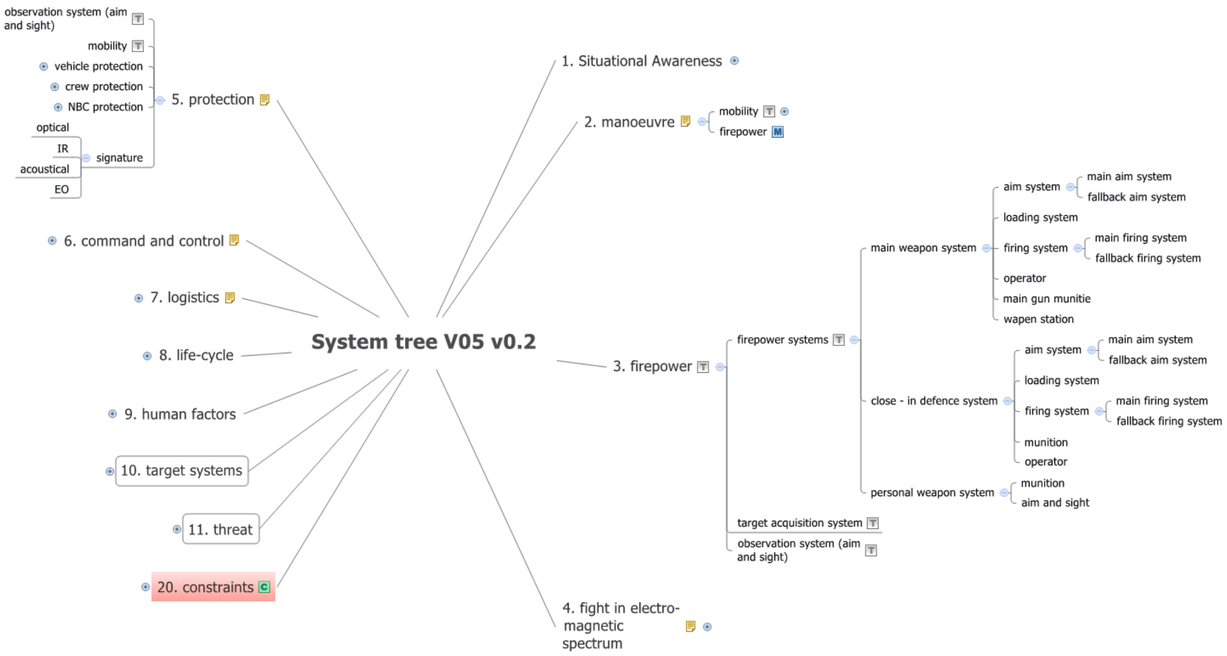

Figure 3: Example of parts of the generic system tree.

- communication system

The communication system contains all components that enable communication with higher and lower echelons and the system internal communications.

- transport system

The transport system contains platform elements which are related to transporting people and goods. For instance loading space for transport of munition, personnel space for transport of military personnel, supportive means such as ramps, winches and tow cables to transport other platforms.

Note: The selected elements themselves are part of the operational requirements.

The selected task and environmental aspects act as a filter on the generic system tree. The relevance of a specific system for the selected environments and tasks determine whether a system is used in the generated system tree. A sea platform does not need wheels or tracks, but screws. And the generated system is an aid to the OR developper as well. It provides a check list of components on what requirements need to be posed.

To generate a system tree the libraries are searched to detect subsystems and components which are suited to perform the selected tasks. With the selected systems each node provides a set of related characteristics, with which the various node functions and components can be further specified and with which the OR developer is able to indicate the detailed requirements.

As an example consider the following situation. One of the systems needed for an observation task is a sensor system. If required target systems include personnel, and the relative distance is short, there is no need for a long-range sensor system. Therefore the generated system tree will not include such system.

2.6 Enter what attributes need to be addressed

System tree nodes contain sample characteristics. The set of characteristics is used to fully specify the subsystem/component. Only relevant characteristics are used in a specific situation.

For selected characteristics normative values are entered. Filling in attribute values further registrates requirements. Attribute and attribute values are the performance parameters of the system under consideration.

characteristic	dimension
range	[m], [m]
minimal target size – distance profile	[m] x [m]
frequency range	[Hz] – [Hz]
zoom range	[m] – [m]
angle of sight	[rad]
user friendliness	# buttons; # acts;
sight conditions	light, dark, smoke, etc.
sensitivity to surroundings	interference
sensitivity to terrain	
sensitivity to weather	e.g. min. 80% of nominal performance in rainy conditions; min. 50% of nominal performance in snowy conditions;
sensitivity to climate	
detectability	
sensitivity to pressure (height, depth)	[kPa] – [kPa]
supportability	# parts; mean repair time; complexity of repair, e.g. number of components to handle;
load to surroundings	dangerous goods; toxics

Table 1 Example characteristics of observation systems.

2.7 On mission dependent add-ons and mid-life upgrades

Mission dependent add-ons and mid-life upgrades assume an existing platform. New and changed requirements need to consider the existing platform. Fulfilling the requirements is constrained by the characteristics of the existing system.

Mid-life upgrades have a permanent character and are aimed at foreseen future use of the vehicle. Usually higher reguirements are requested. When a weight margin was introduced during the design of the original vehicle, it might be consumed by the mid-life upgrade. However in practice careful balancing will be required to fulfill the requirements within the weight 'budget'. When a vehicle has been designed with future enhancements in mind, options might be available to increase the weight margin, most likely challenging the financial 'budget'.

Mission dependent add-ons are temporary adaptations that are expected to give more options to fulfill the current requirements. For instance, additional protection against anti-tank weapons, which increases the weight, can be applied at the cost of a weight reduction in some other area, always considering operational context.

An important aspect system in this context is the 'balancing factors' aspect system. It includes aspects that act as constraints within a platform, such as weight and cost. The aspects mentioned usually are restricted by a certain budget, e.g. maximum weight. Adding weight then to a subsystem needs to be compensated by reducing weight in another subsystem. Balancing between requirements and solutions will always be a compromise. The OR development support tool is helpful in that it contains a set of balancing aspects which are included in the OR development process.

3.0 SOFTWARE: OR DEVELOPMENT SUPPORT TOOLS

3.1 Development of operational requirements

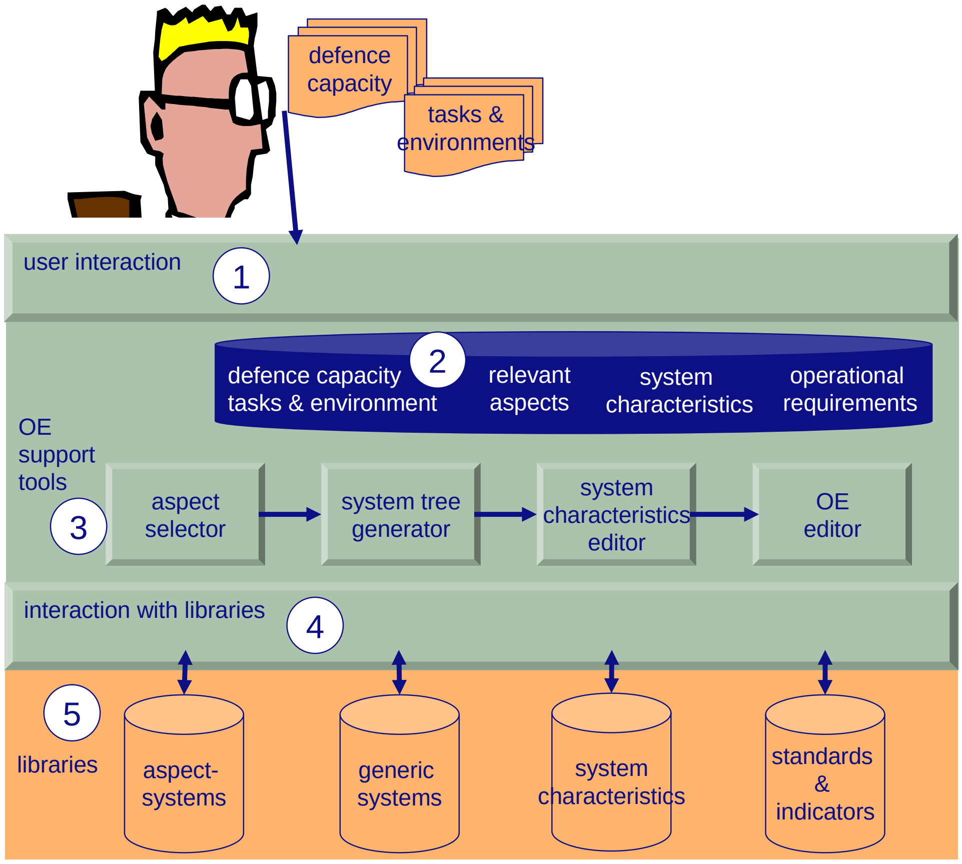

Figure 4: System overview of support tool.

To support the process a software tool is currently under construction. The tool contains libraries with predefined, generic systems, tasks, aspects, environments and system characteristics. Figure 4 shows the systems architecture for the support software. Part 1 takes care of interaction with the user. Part 2 is the data store where input, selections and resulting information is stored. Part 3 comprises the tools which support the process, such as selector for aspects, generator for system tree and editors for adaptation of characteristics and the actual Operational Requirements. Interaction of the tools with the libraries takes place in part 4 and part 5 contains the libraries. Some screen shots of examples have been added:

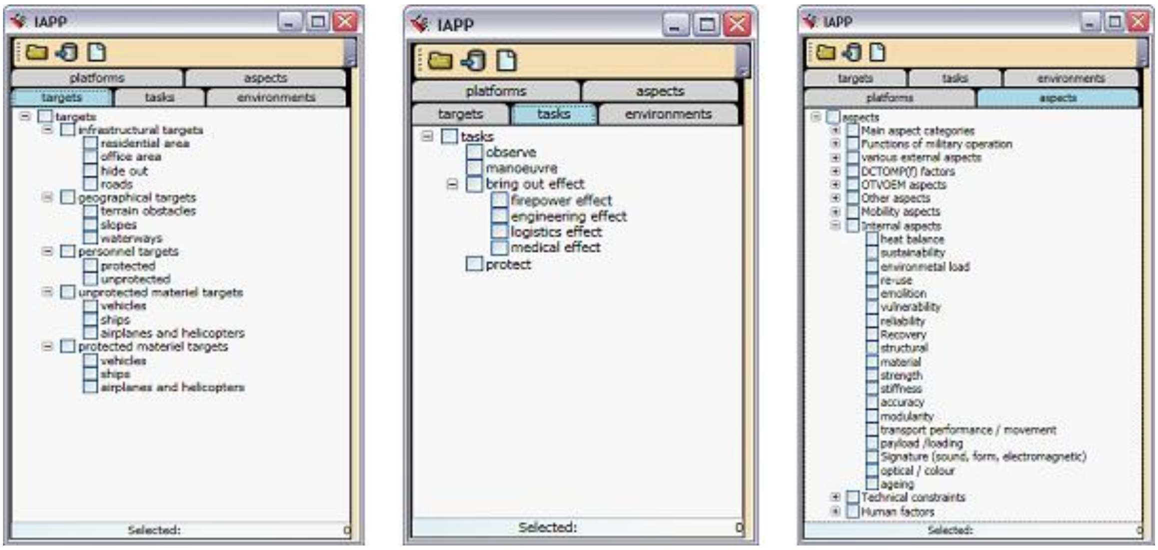

Figure 5: Screenshots examples of support tool.

3.2 Balancing operational requirements

A system analysis tool (figure 6) is being developed to investigate the consequences of changed requirements to existing vehicles. Requirements changes are restricted to the application of new technologies. The consequence of selecting a particular solution is determined in an integral way, showing the effects on e.g. mobility, lethality and survivability. Balancing aspects weight, action range and available space are used to integrally optimise a vehicle.

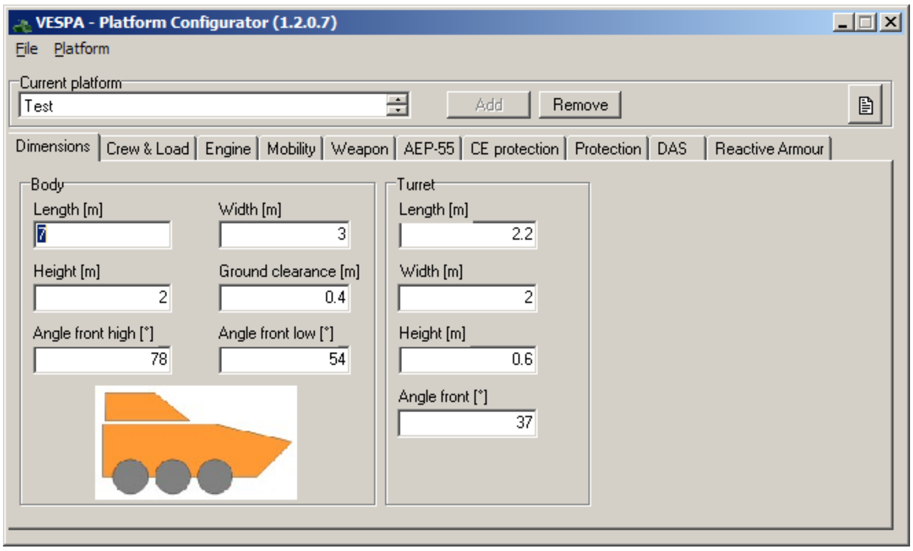

Figure 6: Interface of the system analysis tool.

4.0 CONCLUSION AND FUTURE WORK

A method has been introduced to support an integral approach to the development of Operational Requirements. An integral approach means that OR are introduced for many aspects, sometimes resulting in conflicting requirements. For instance requirements on low infrared signature in arctic environments might conflict with the need for sufficient heating and ventilation for the platform crew. Conflicting requirements usually introduce extra work and anomalies in design. And platform size restrictions might conflict with necessary space for personnel.

The method is currently under evaluation. Although we expect to increase the quality of future OR because of the integral approach further investigations and testing of the method and the tools are necessary. These topics may be reported in future publications.

For the description of military platforms a lot of restrictions are being posed upon. A long list of STANAGS and other standardisations are used during the specification of a platform. A future development is to enable on-line querying of these standards, rules and regulations. A subsequent step is the evaluation of requirements against the standards.

A future application of the system analysis tool is to investigate future vehicle improvements. Conflicting situations can be uncovered and using sensitivity analysis requirements for development can be determined. A strong interaction with the armed forces is needed to account for foreseen or desired changes in missions and consequential changes in requirements.